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Use a Single FM Microwave Link for two Black-and-White Cameras

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Abstract. Many microwave systems today transmit high-quality video signals. Some of these systems are outstanding in quality, with technical performance significantly better than that needed for the application. If this is the case in your installed link, you may be able to use this "excess" performance to your advantage and add another independent video channel. You can probably do this without any modification to the operating license, as long as you don't exceed the bandwidth limitations. This approach effectively conserves valuable space in the radio frequency spectrum.

Introduction

At Lawrence Livermore National Laboratory, a remote surveillance need is being met by using a microwave link to transmit a single black and white camera signal to a control point about six miles away. Lately, another camera was needed to increase coverage to include a wider viewing area. An interim solution was to synchronize the two cameras, and mix their signals to provide a single video picture in a split-screen format. A natural long-term solution would have been to use a separate transmitter-receiver pair on the same antenna system. This would have required obtaining another channel license and another full set of video equipment, a lengthy and expensive process. Before proceeding, the existing installed link was evaluated.

Evaluation of the Link

The microwave link is a Terra-Com TCM602, operating at 4.875 GHz, with a power output of 1 W. The antennas are six feet in diameter and the path length is about six miles.

The baseband signal is being transmitted with a signal-to-noise (S/N) ratio of greater than 60 dB. This is 20 dB better than the normal picture obtained from the black and white camera being used. In turn, the camera signal is better than the resolution (both in detail and S/N ratio) of the motion detector system with which the camera is being used. The transmission path is not subject to much fading. The unequalized bandwidth is over 15 MHz. This microwave link performance represents a significant "excess" performance for our original application.

Our evaluation of the link baseband performance is summarized in Figure 1.

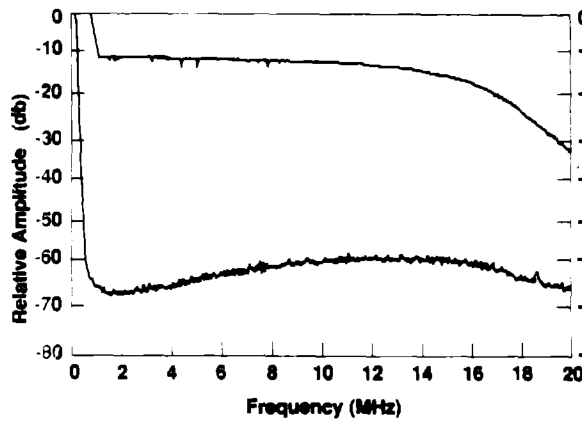

Figure 1. Microwave link capacity.

The baseband equalization normally included in the link was removed for this test. In the figure, two separate

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spectrum analyzer measurements are superimposed;

1. The noise floor with no input (bottom curve), and
2. A maximum level sinusoidal input (top curve).

The area between the two curves indicates the amount of signal information that can be transmitted. Figure 2 outlines the

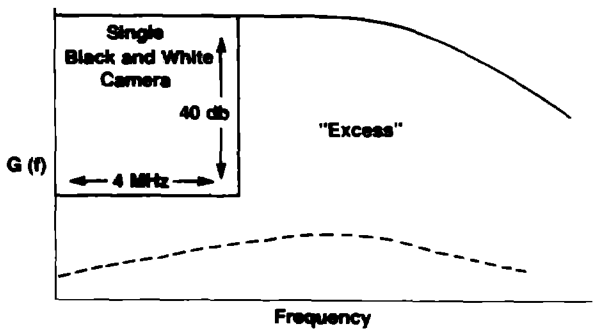

Figure 2. "Excess" capacity.

area that is needed to transmit the signal from one camera. The remaining area is unused and is the "excess" capacity referred to in this paper.

The System Design

One way to use this "excess" capacity is to apply the technique of Frequency Division Multiplexing (FDM). The placement of a Vestigial Sideband Amplitude-Modulated (VSB/AM) carrier in the frequency band above the single black-and-white camera band can effectively use the channel capacity. CATV channel T-7 occupies the frequency band from 5.75 to 11.75 MHz and is ideally suited for use here. T-7 hardware is readily available from a number of commercial sources. The frequency plan is outlined in Figure 3.

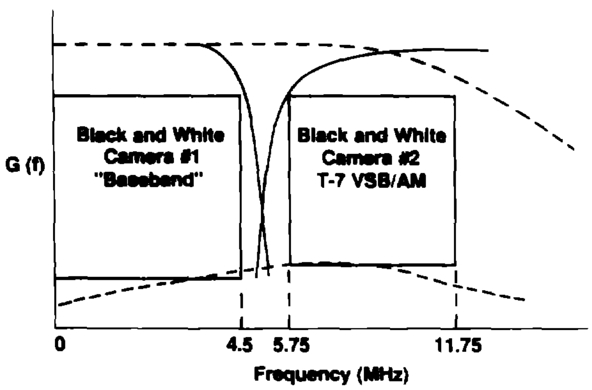

Figure 3. Multiplex baseband spectrum scheme.

Figure 4 is a block diagram of the transmitter site. Because the main carrier is FM modulated, the dynamic range of the channel must now be divided between the two separate analog baseband signals. The standard video-input amplitude (1 V peak-to-peak) must be properly proportioned between the T-7 carrier and the Camera-1 signal to prevent signal degradation from cross modulation. An effective compromise is to reduce the video level of Camera 1 by 20 dB, which is approximately the loss in S/N ratio that can be accepted in its transmission performance. This leaves room for inserting the T-7 carrier energy in the baseband through a bandsplitting filter, as shown in Figure 4.

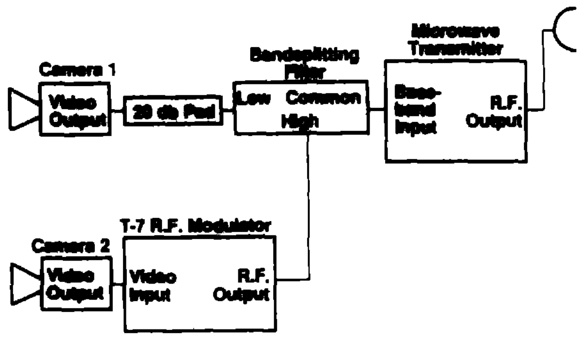

Figure 4. Transmitter site configuration.

As previously mentioned, the pre-emphasis networks have been removed from the system, so that the spectral components are transmitted with the response shown in Figure 1.

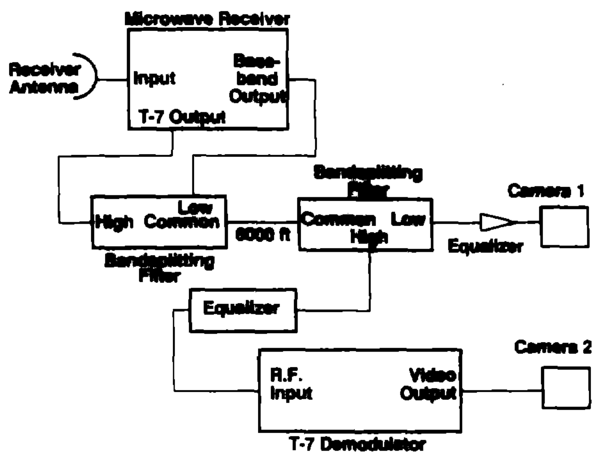

Figure 5. Receiver site configuration.

Figure 5 shows the receiving site configuration. The Terra-Com receiver has an auxiliary output, which is used to recover the T-7 signal separately. The main video output of the receiver has sufficient gain to make up for the 20-dB loss inserted in the transmitter. In our application, the receiver antenna is located 6000 feet (1.3 km) from the microwave receiving site. The two camera signals are recombined by the bandsplitting filter, so that a single cable can be used. At the receiver end of this cable run, another identical filter is used to separate the two camera signals for demodulation and equalization. A passive equalizer is used for T-7 channel compensation, and an equalizing video distribution amplifier is used for the "baseband" channel.

System Performance

The overall system performance is a compromise between the video S/N ratio and crosstalk between channels. When two separate signals are combined in this manner, nonlinear transmission characteristics are very important. The deviation limits on the main carrier and the ratio of the video to the T-7 carrier were determined empirically, with test signals simulating operating conditions.

The RF-input level to the receiver is the most important contributor to the overall S/N performance. In our case, the input level was -32 dBm. (This is the level used to produce Figure 1.) The specified receiver threshold is -78 dBm. Performance was also evaluated for a 6 dB fade (input = -38 dBm). The S/N data are shown in Table 1. The measurement was made using a flat-field monochrome test generator for a source.

Table 1. S/N Performance Measurements.

SIGNAL LEVEL	S/N MAIN	S/N T-7
-32 dBm	52 dB	44 dB
-38 dBm (6 dB fade)	47 dB	42 dB

To achieve this performance, the receiver's FM demodulator must be carefully aligned. The best option was to use two nonsynchronized video test signals and observe the crosstalk on a waveform monitor locked to one of the signals. A multiburst signal was input to T-7, and a flat-field signal was input to the "baseband". By minimizing the crosstalk of the multiburst into the flat field, the detector can be linearized over the widest possible bandwidth. (Incidentally, if the two signals are locked together, the crosstalk is further reduced since it is worst during sync pulses and is not as detrimental to the active video.)

Although our application was for black-and-white cameras, we also used NTSC color signals while testing the system to determine the usefulness of this approach for color cameras. We found that there was not adequate linearity to prevent crosstalk between the second harmonic of the color subcarrier (3.58 MHz) and the T-7 video carrier (7 MHz). Annoying beat patterns were observed in the T-7 video modulator output when the main channel had a high color content. To reduce this chroma crosstalk, the deviation and level of each of the two signals had to be reduced. The resulting S/N ratio of each was reduced to about 35 dB. A possible solution might be to shift the T-7 channel carrier to a slightly higher frequency, but this approach was not evaluated.

Conclusions

For a short-path microwave system with "excess" capacity, it is feasible to use the link for transmitting two independent monochrome surveillance-camera signals. This method is economical. It saves the cost of buying another transmitter/ receiver pair and the time spent on the licensing procedures. The RF spectrum conservation aspects can also be important, since another channel might not even be available.